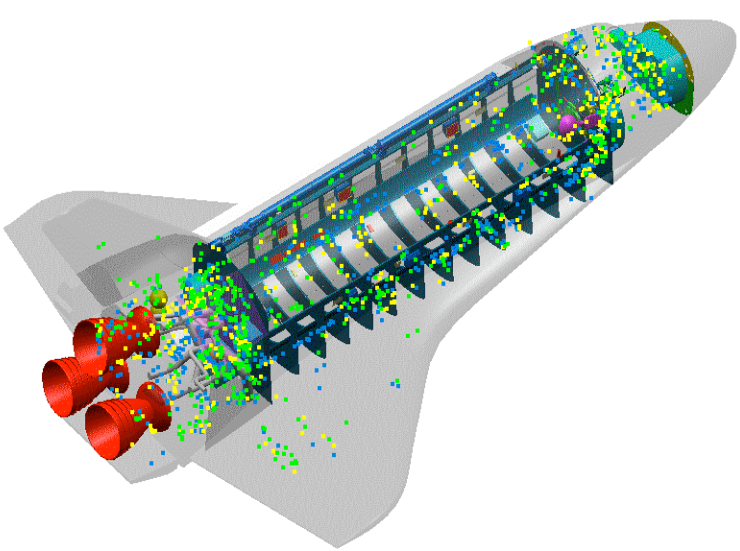
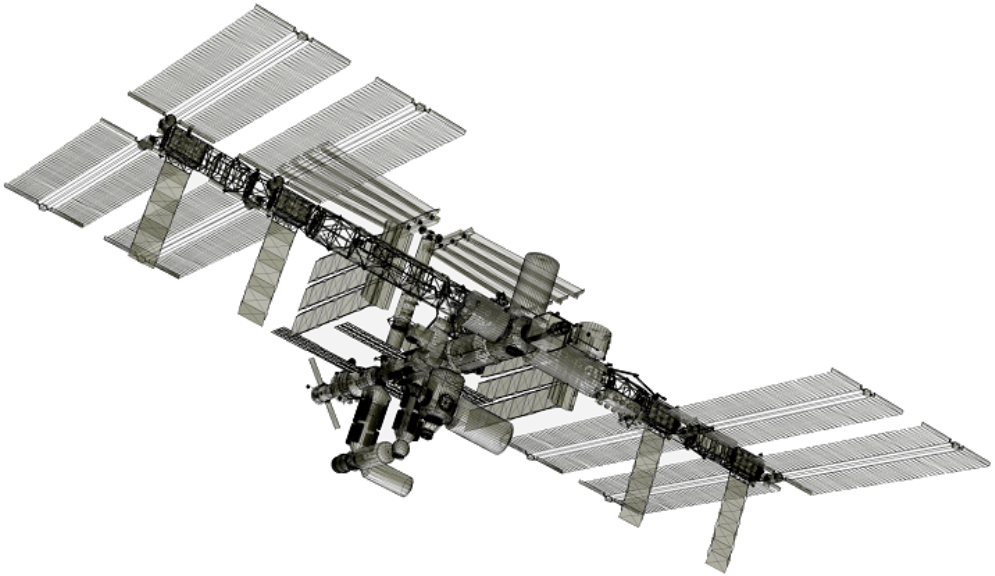
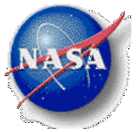




Virtual Iron Birds

Knowledge-Integrating Virtual Vehicles

Dr. Mark Shirley

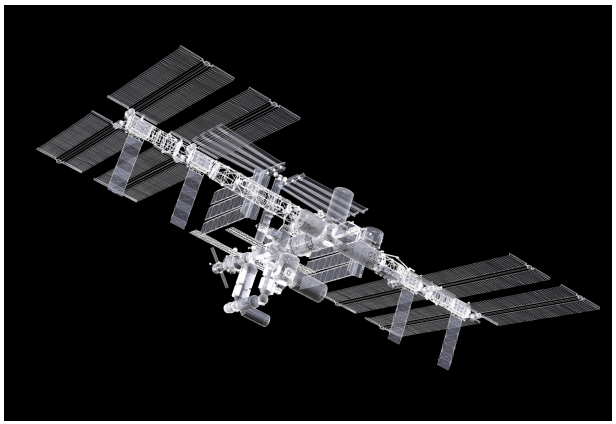


Outline

- The Common Problem
- Work related to Shuttle
- Work related to Station

What problem are we working on?

The Challenge: Managing the ISS is proving much more difficult than anticipated



- The system interactions are growing more complex as construction proceeds
- No physical full-vehicle 'Iron Bird' is feasible
- To get an integrated, coordinated view is tedious, if not impossible
- Investigating anomalies and conducting "What-If" studies requires combining information from many sources and is very labor intensive.

How NASA solves these challenges will form the baseline for future missions, e.g., OSP

Innovation in IT technologies is a part of the solution

Results from SSP Ontology Context Study

"My group spends most of its time researching data and/or requesting non-accessible information from other companies and contractors"

"Today, geometry is in one database, part numbers and general notes are in another…"

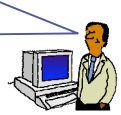
"Part numbers are different in different systems, there is a need for a common coding scheme"

"If I want to look into the wing glove bracket, where do I start? I have to talk to engineers, someone will say "I think it is in this system"…"

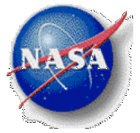
"Each time you start working on a new part of the subsystem, someone has to show you where to find information. I would never be able to figure this out for myself"

"A lot of information is documented, but it is not connected and in many cases is in paper form"

"We have crew debriefs and lessons learned sessions, but where does that information reside?"



"There is a queue of people who will be retiring within 5 years"



Our Focus: Lack of Integrated Knowledge Models

- Central Issue:
  The Shuttle and Station Programs have heterogeneous data sources and no integrated knowledge models
  - Difficult to navigate, use, integrate, synchronize, extend
  - Numerous legacy system problems

- Complicating Factors
  - Geographically dispersed workgroups from different organizations
  - Contracts mediate information sharing behavior

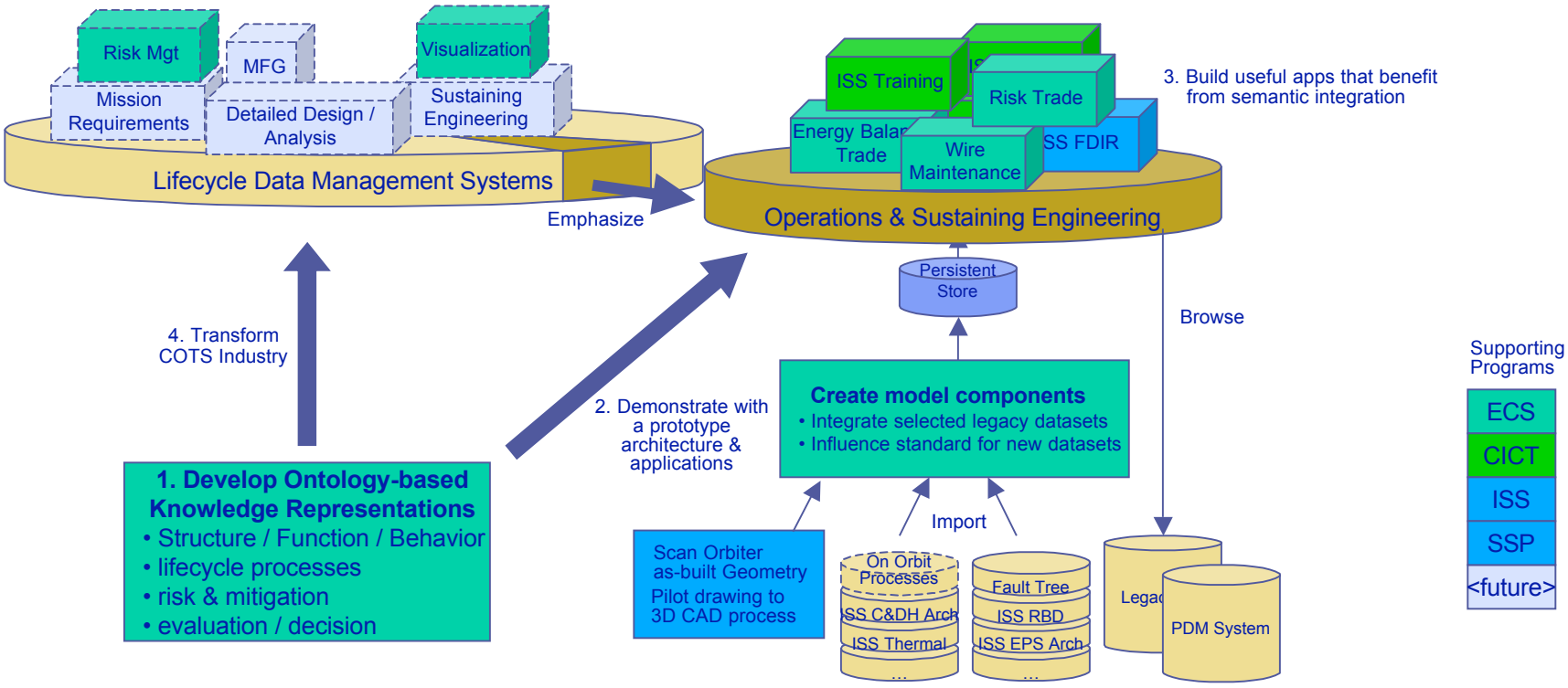
- Consequence:
  Difficult to support effective organizational learning and systematic introduction of lifecycle-consistent risk models

Virtual Iron Bird Approach

1. Provide a semantic foundation for integrating models across the enterprise
2. Prototype by building models to show integration across significant Shuttle and Station datasets
3. Demonstrate utility by partnering with SSP, ISS & CICT to build applications with the integrated datasets
4. Lock in advances by partnering w/ COTS industry and influencing NASA procurement policy


Shuttle

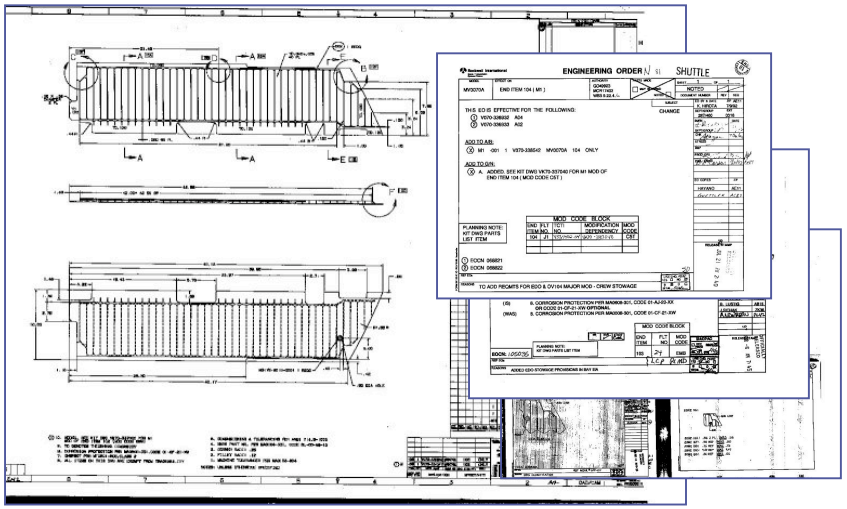

Station

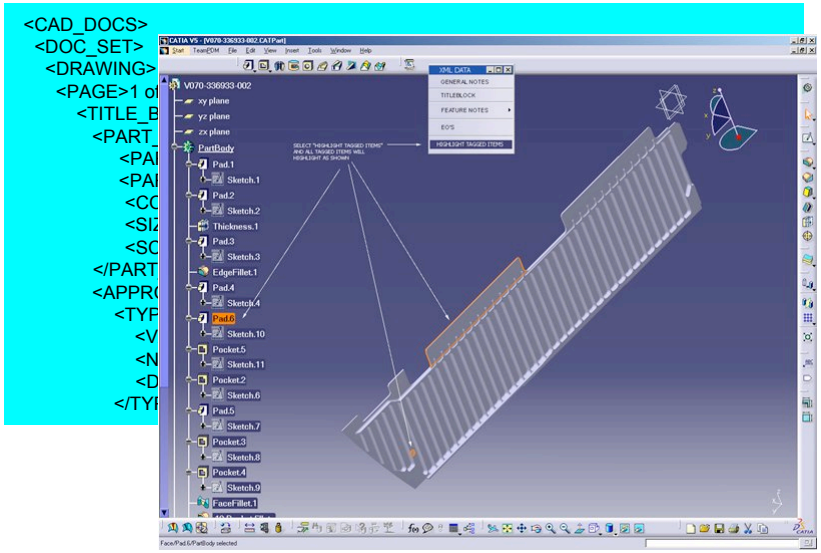


Outline

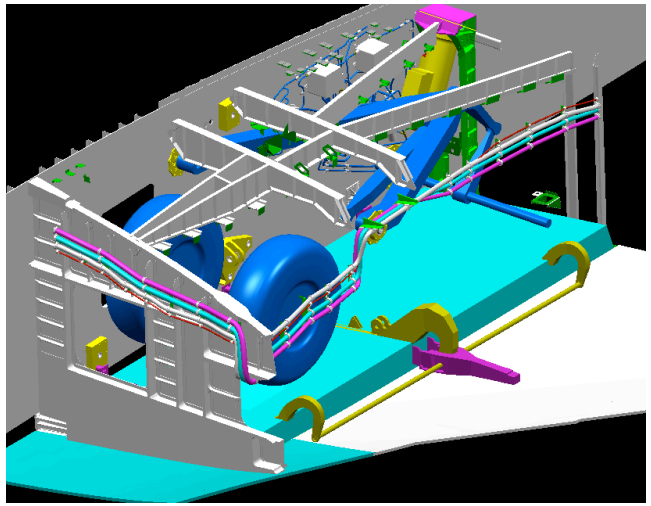
- The Common Problem
- Work related to Shuttle
  - Getting basic data into electronic form
  - Partnering with SSP to address enterprise knowledge management issues
- Work related to Station

Digital Shuttle
As-Designed drawing conversion

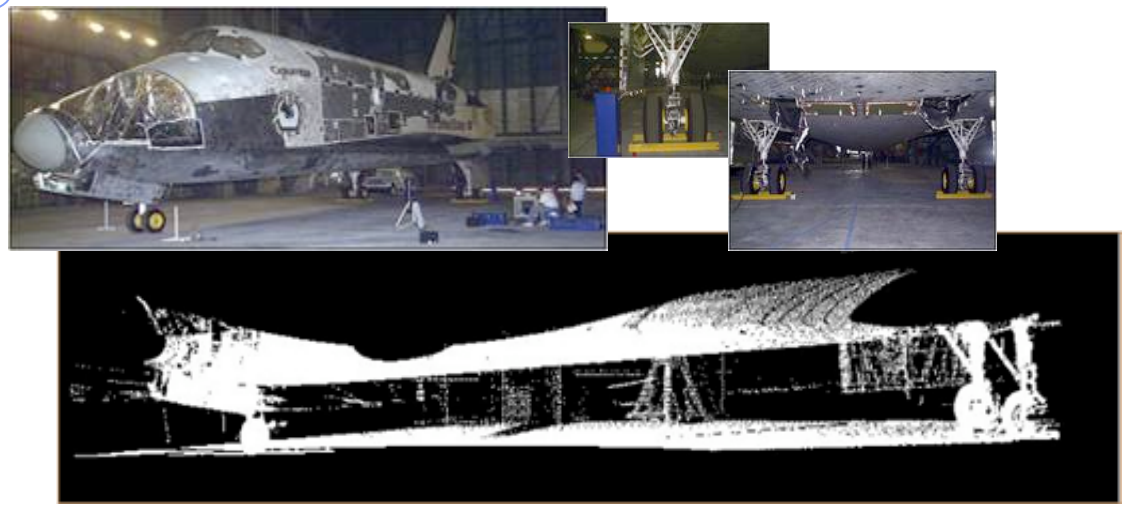


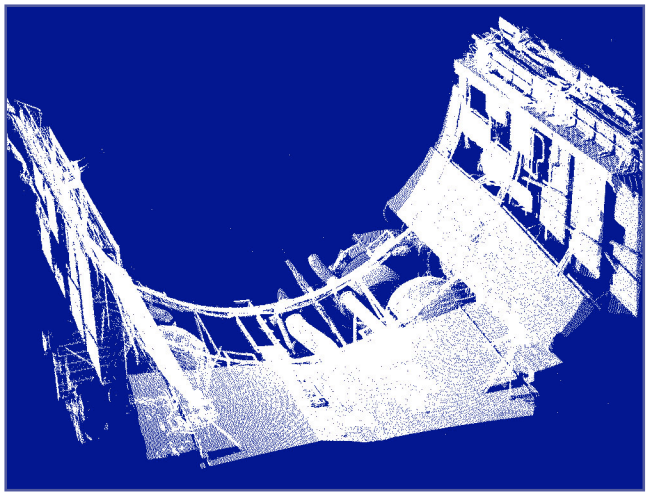


- **Issue**: Over 1 million drawings and Engineering Orders per orbiter
  - EO's not integrated into drawings
- **Response**: Convert Orbiter drawings, incorporating EOs, into 3-D CAD models
  - Capture non-geometric information too
  - Incorporate into Shuttle Ontology
  - Provides accurate engineering models for multiple uses
  - Technology pathfinder project underway

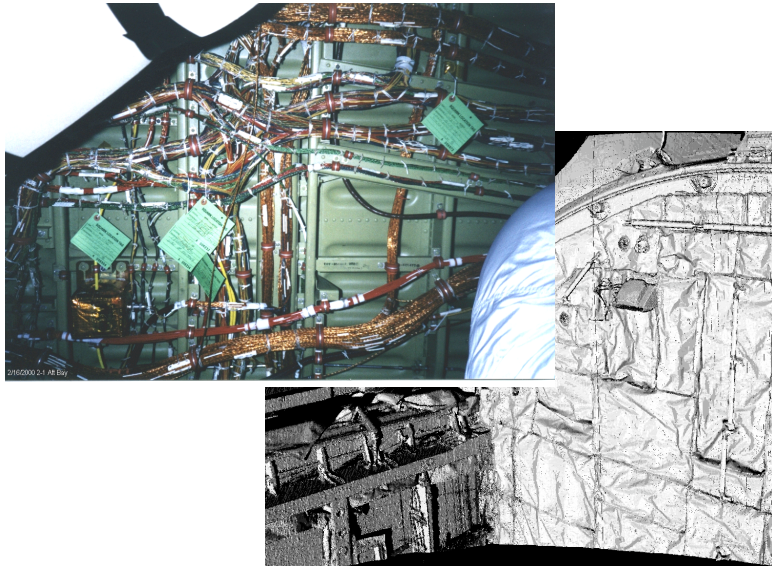


Digital Shuttle
As-Built / As-Maintained Digital Modeling



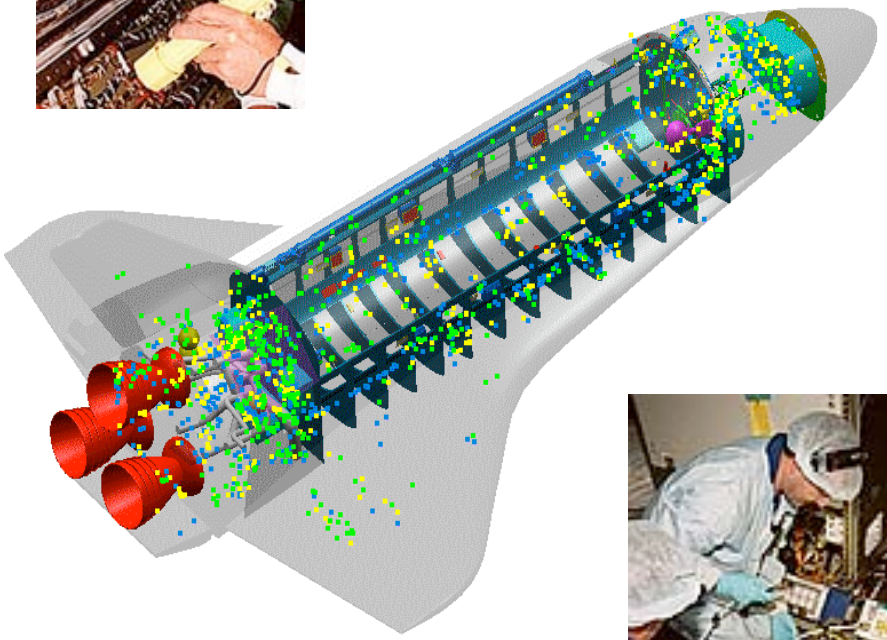


- Scan all Orbiter areas to create accurate 3-D CAD model
  - Method for virtual assembly and digital mock-up, resolve as-design differences, location identification, process planning, analysis
  - Provide spatial attributes to Ontology
  - Technologies: laser scanner, laser tracker, photogrammetry, white light scanner

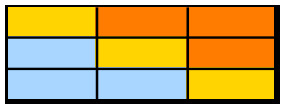


Contact: Paul Keller, ARC

Wire Integrity Research Project
Going from labor-intensive inspections...



…to risk-advised maintenance...



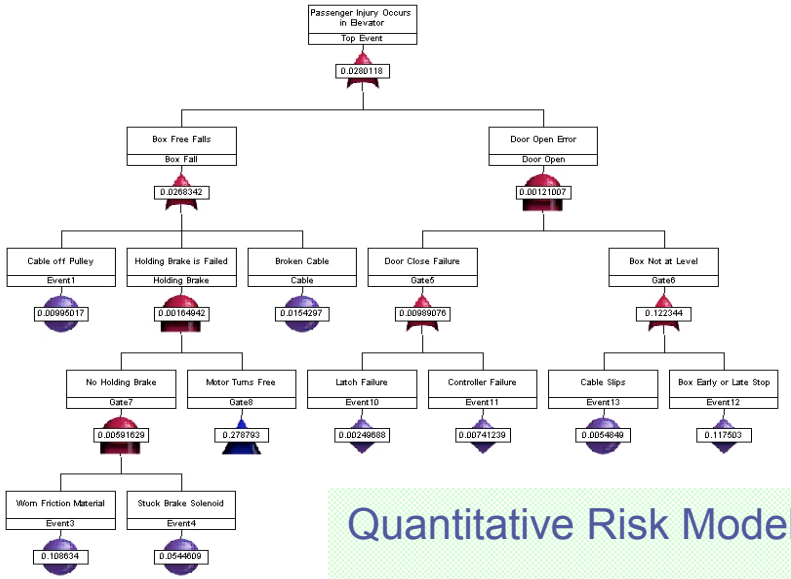
Probability

Consequence

High Risk Area

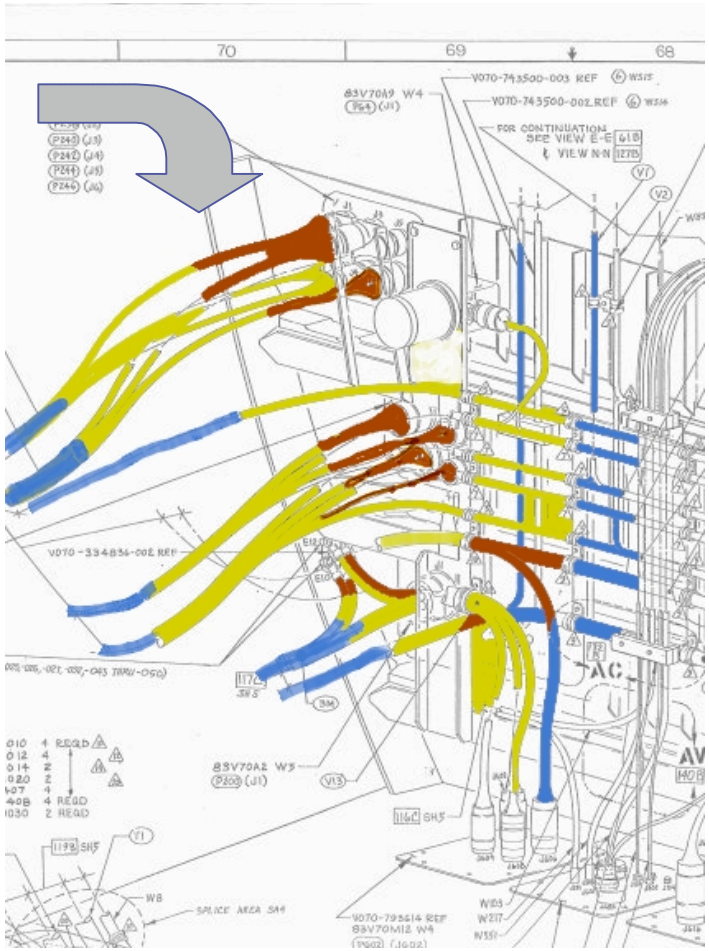
Med Risk Area

Low Risk Area



Quantitative Risk Model

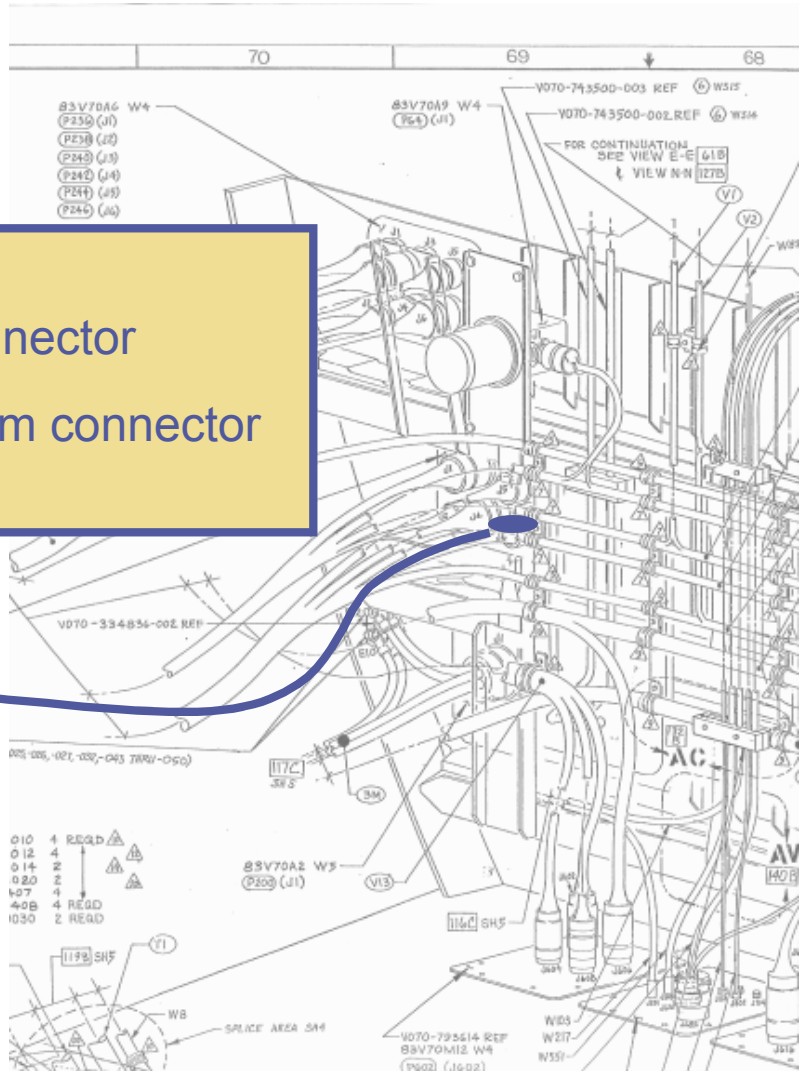
(including Human Factors)



…with automated wire integrity assessment

Open Circuit - 4.35m from connector

Insulation damage - 2.75m from connector



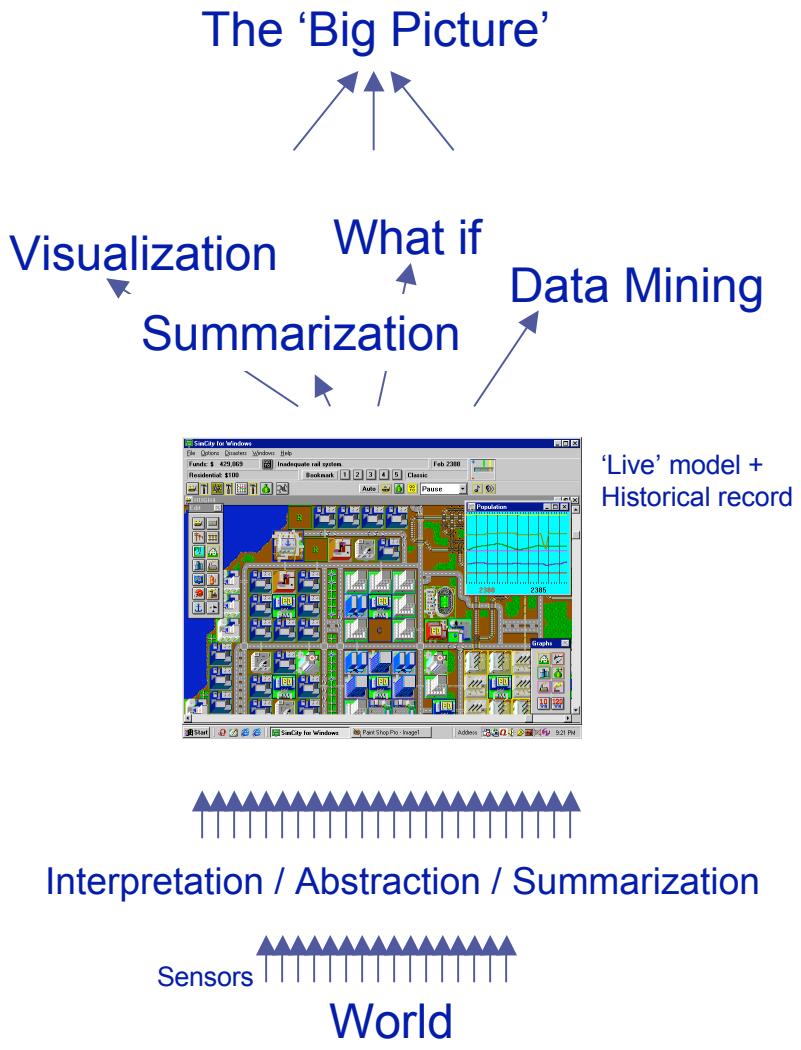
Contact: Jim Cockrell, ARC

Outline

- The Common Problem
- Work related to Shuttle
- Work related to Station
  - Existing electronic data lets us focus on a richer vision

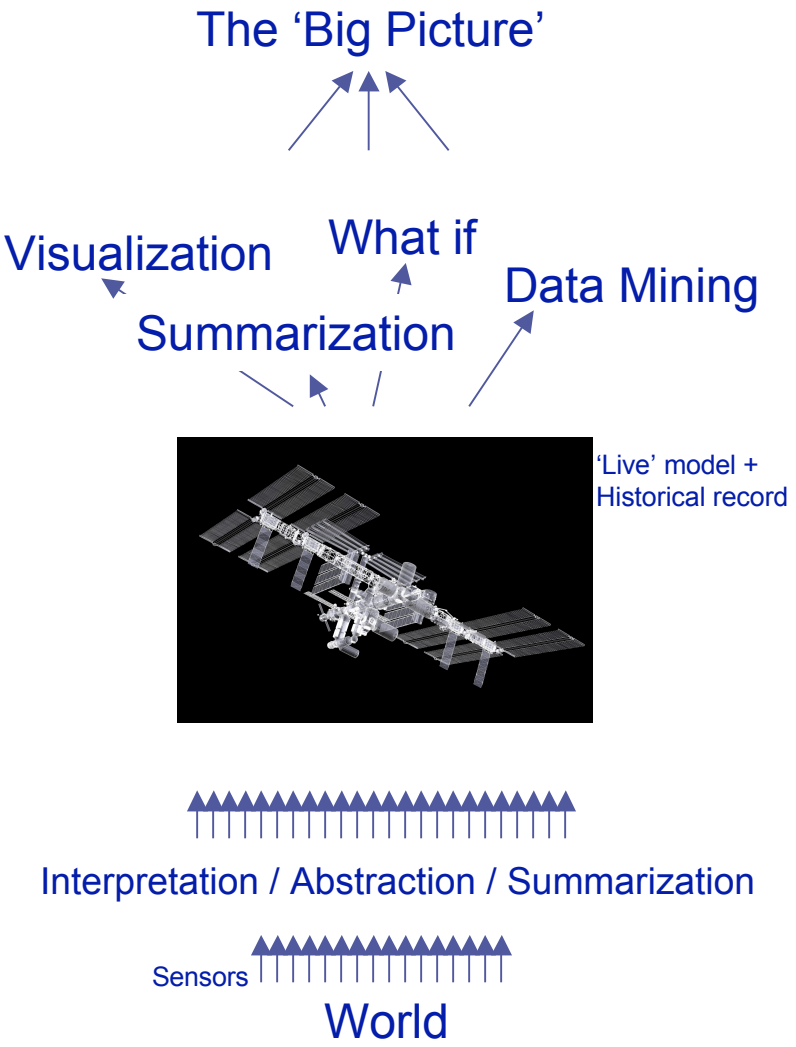
Mirror Worlds (Gelernter '91)
Theoretical Underpinnings

- Mirror World goal:
  - Provide an environment for understanding and solving complex problems
- Examples
  - City Management
  - Hospital
  - Building environment control
  - Inspiration for Digital Earth
- Not Mirror Worlds (but related)
  - Joint Strike Fighter
  - Boeing 777

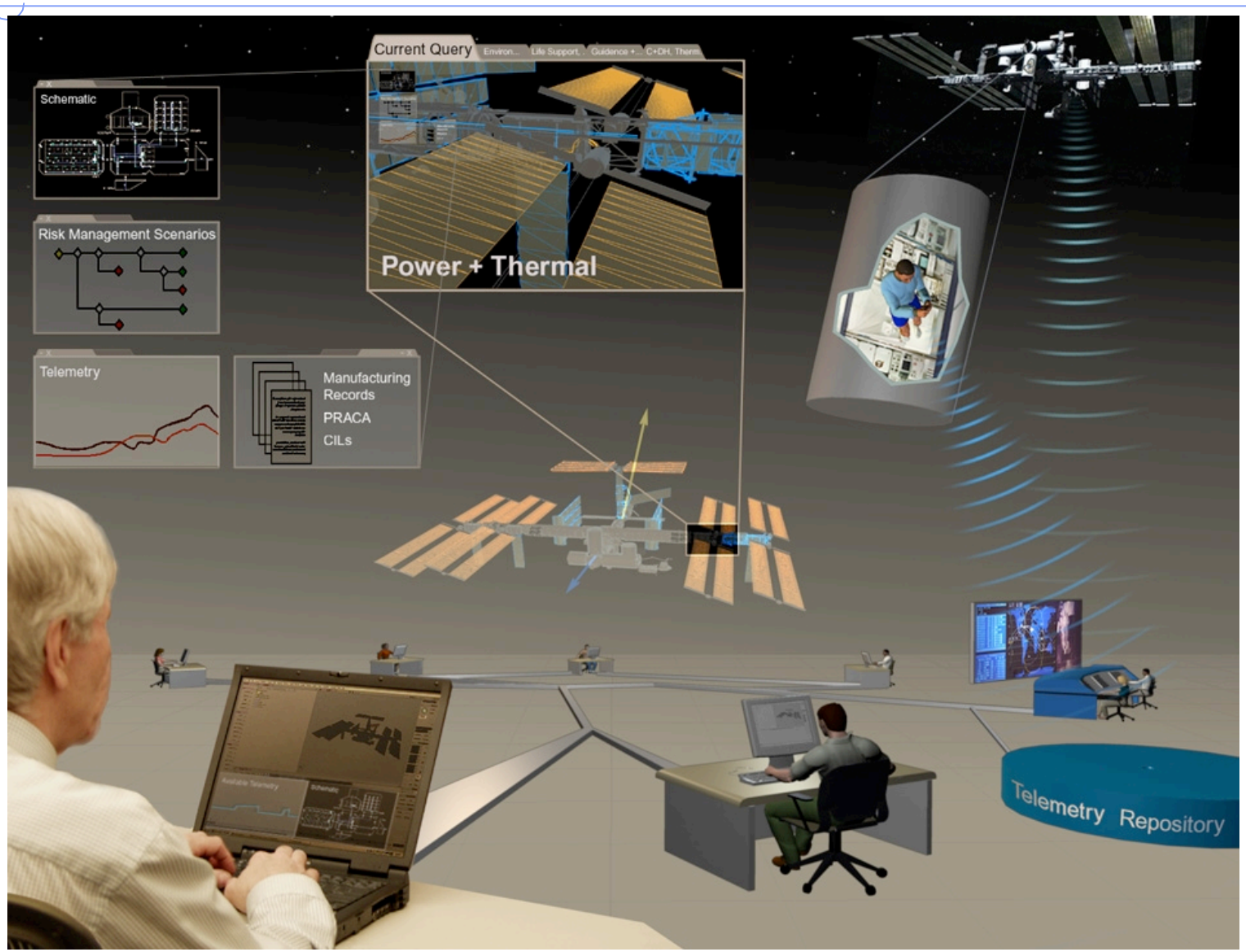


Mirror Worlds (Gelernter '91)
Theoretical Underpinnings

- ISS is a pacing application for this question
  - DoD & DoE operate high-risk, high-complexity systems but don't focus as many people on a single thing, nor in the open
  - ISS is ripe for this work due to availability of data



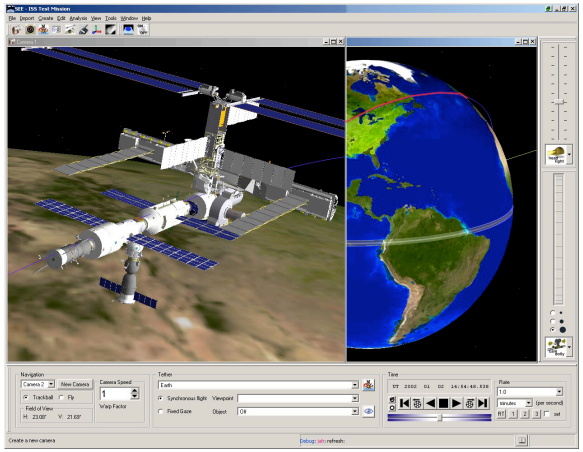
Our Goal: An ISS Mirror World



- A portal to ISS engineering datasets
- Organized by an integrated, managed data model
  - Structural: Where are the parts? How are they connected?
  - Functional: What roles do they play?
  - Behavioral: Under what conditions will they do that? How can they fail?
- Access to telemetry with software agents for data-mining and monitoring data streams
- Behavioral models for what-if analysis
- An extensible problem-solving Environment

Selected Components of this Mirror World

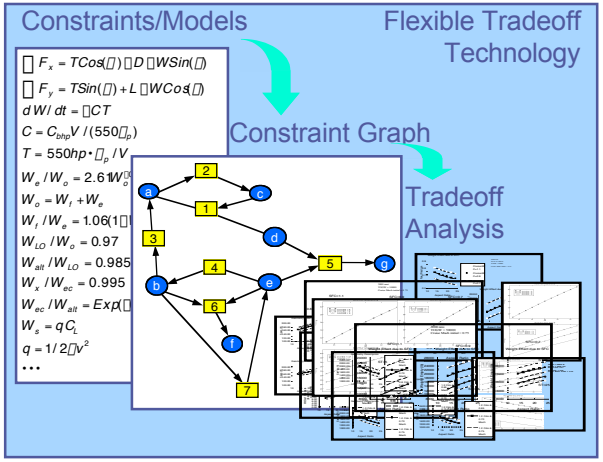
SEE – LaRC (ISE Legacy, extended w/ ECS & ISS funding)



- Orbit/Attitude
- Editable vehicle config
- Rigid Body Dynamics
- Exterior visualization
- Visiting Vehicles
- Instrument visibility
- Lighting on solar arrays

In use by ISS VIPER team

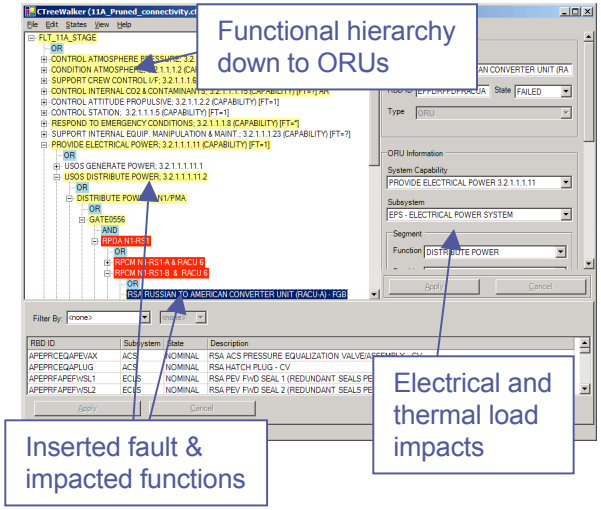
SimStation – ARC/JSC/Rockwell/Boeing



- Behavioral quick-look trade & optimization tool
- Plotting
- MBSU switching model & battery charge/discharge model

Under development

SEaCLIF: ISS Architecture Model -JSC/ARC



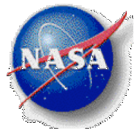
- Component / Connection / Function model of ISS
- Integrated from existing ISS datasets
- Fault insertion & examination of down-stream impacts on critical functions and electrical & thermal loads
- Sources: Boeing Reliability block diagrams, EPS, thermal & C&DH architectures

Under development

Intelligent Virtual Station - ARC

- Visualization of CAD models
- Access to Design documentation
- Visualization of procedures
- FDIR

Under evaluation by SSTF

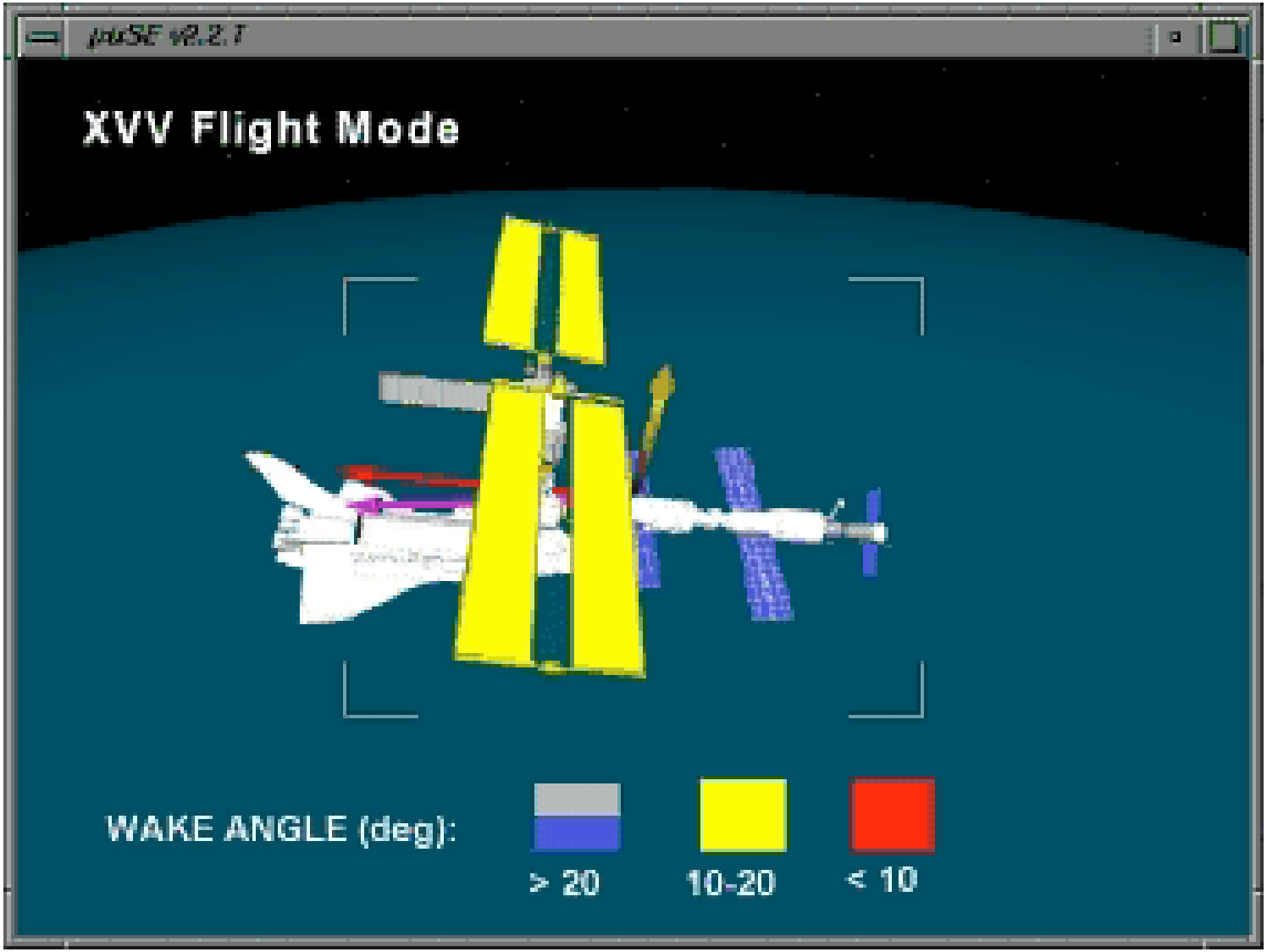


Summary

- Aerospace activities are inherently high risk and require enormous coordination and attention to detail.
- NASA appears to be reaching its limit with current organizational & information management methods …
- Where do we go from here?
- Our conjecture:
  - Much tighter knowledge integration can make the difference
  - We can get there in partnership with CAD industry
  - By demonstrating benefits of integration now, we can get both short-term results and long-term change

Backup Slides

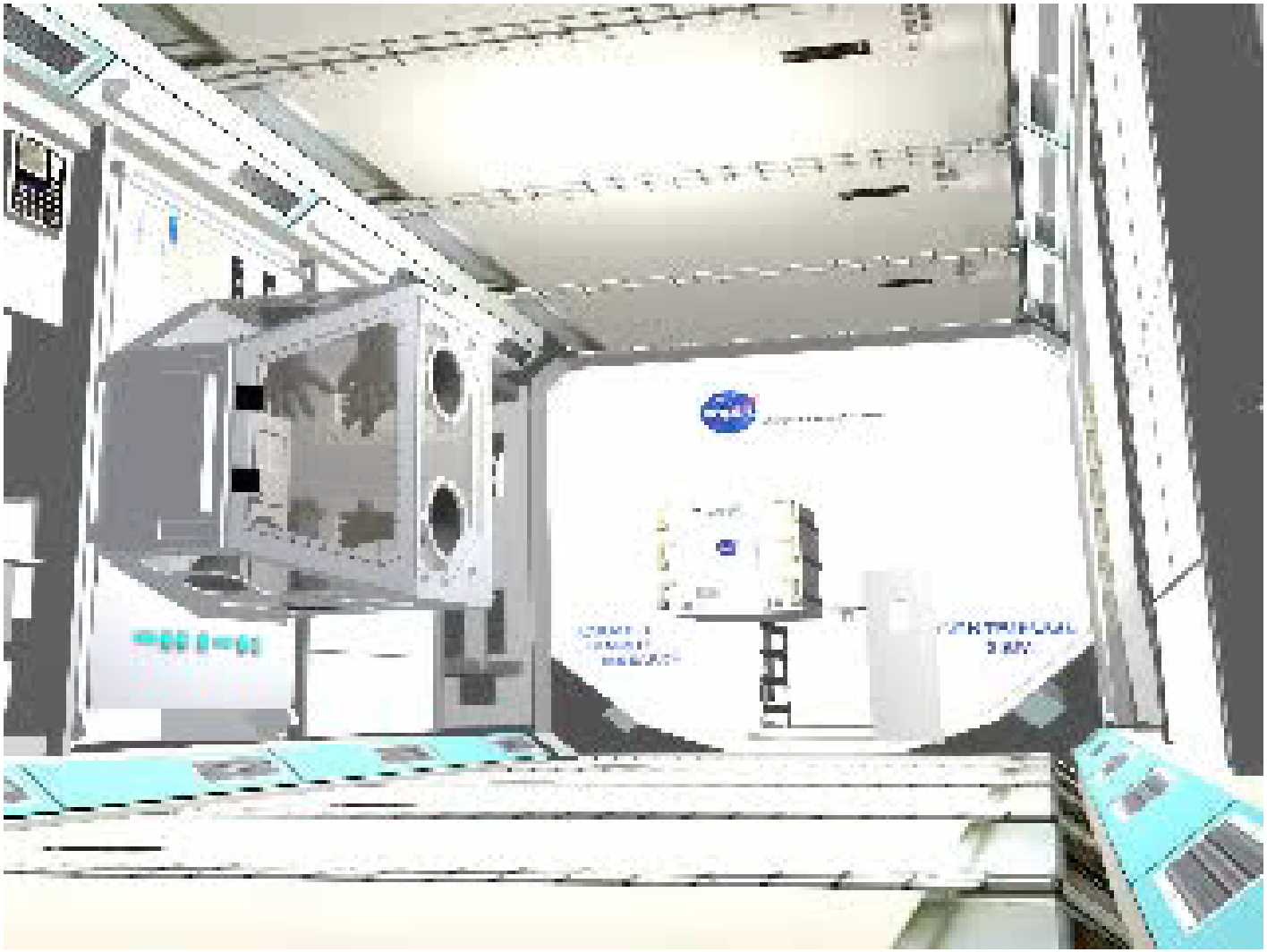
Synergistic Engineering Environment



Contact: Laura Brewer, LaRC

Product of ISE program, extended under ECS & ISS funding

Intelligent Virtual Station



Contact: Robert Mah, ARC

Product of CICT program

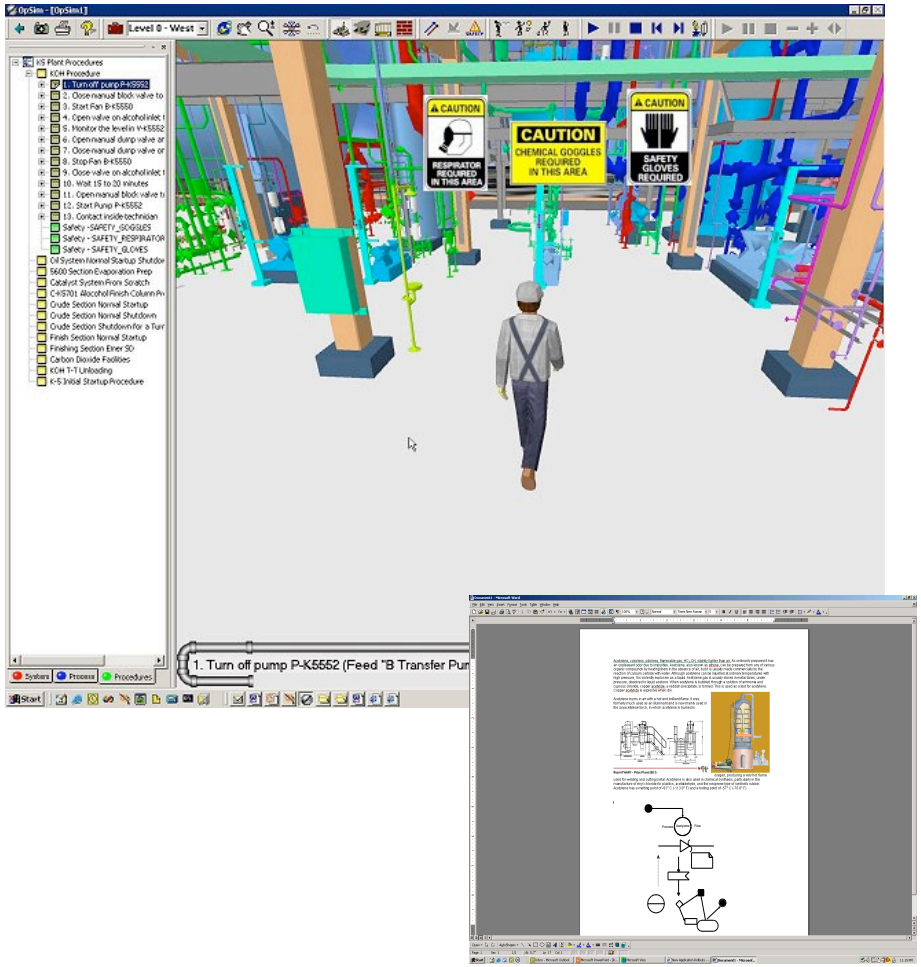
Commercial Partnership under discussion

Reality Capture Inc. (Ames Spinoff)

Product: OpSim

- Procedure Development
  - Write procedures in Word
  - Visualize execution
- Links to document system

- Basis for collaboration:
  - develop Safety & Risk assessment tools
  - infuse into the chemical processing industry & aerospace



Notional KIVVR Technology Roadmap

FY03 FY04 FY05 FY06

ECS

Static Model

Dynamic Model

Scenarios Space

Analysis Capabilities

ISS IVHM Testbed

System Dynamics Trade Tool (SimStation)

Lumped parameter Model-based Hazard Analysis

ECS Wedge

Procedures & Training

High-Fidelity, Physics-based Simulation w/ Uncertainty

Knowledge Representation

Vehicle Ontology

Static Structure / Function Model

LaRC Heads

Discovery Wedge

Telemetry Datastore

Model-based Hazard Analysis including FEA

Infrastructure Architectures

Problem-solving Environment Architecture

Software agents for monitoring telemetry

ISS-in-a-box cluster?

CNIS

Digital Shuttle Technical Accomplishments: Current Status

- Shuttle ontology making good progress
  - High-level ontology documented in series of reports from IBM
  - Co-development of ontology with COTS CAD vendors
    - SAAs in progress with EDS PLM Solutions, Dassault Systems, MCS to embed ontology into their commercial modeling and simulation products
    - Supporting the W3C CAD Working Group Subcommittee
- For avionics bay of the orbiters, completed drawing conversions from blueprints to 3-D CAD "intelligent" models
  - Comprehensive XML definition of non-geometric data associated with the drawings
- Currently engaged in modeling “data clouds” obtained by laser scanning to as-built geometric models of Orbiter
- Draft report of SFOC contract study under review
  - Examines institutional, contractual, and, technical barriers to collaboration and sharing information and knowledge
  - Being reviewed by ECS and SSPO